The impact of targeted observations from 2011 Winter Storms Reconnaissance on deterministic forecast accuracy

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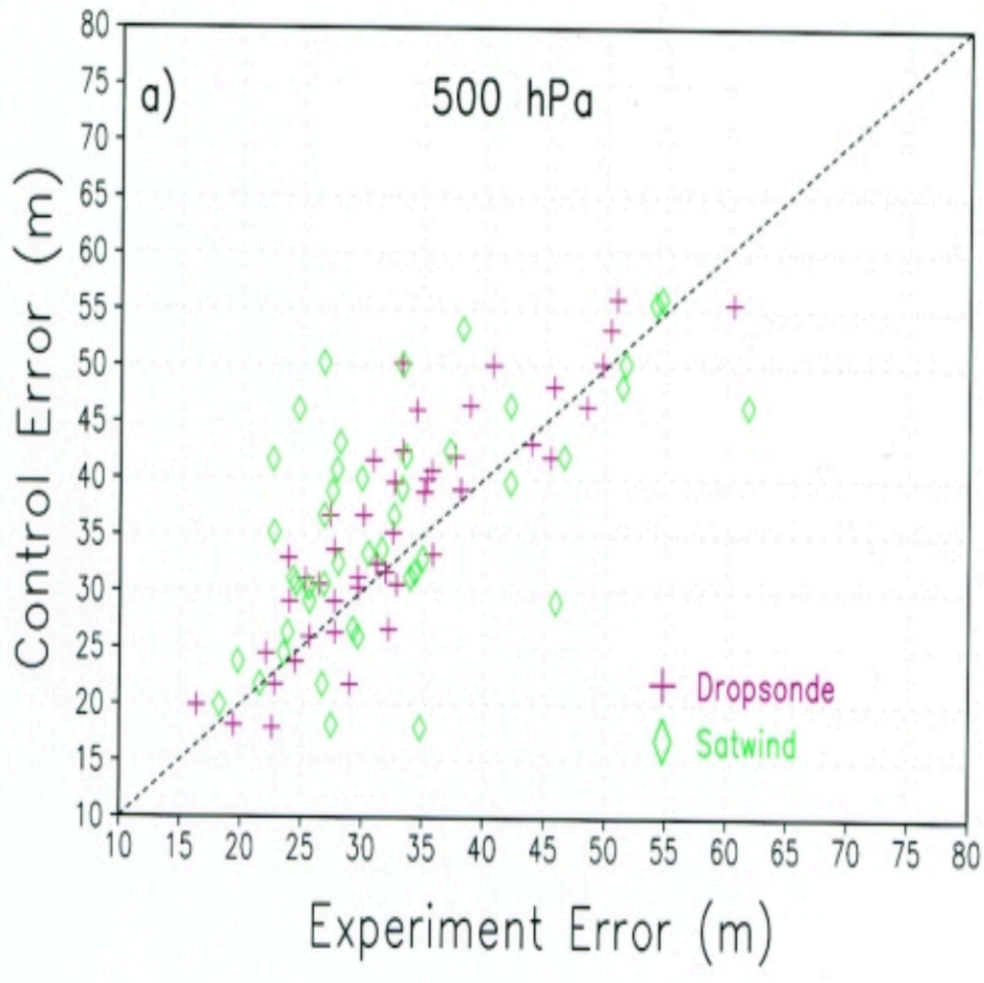
Previously (~10 years ago) there were many optimistic assessments on the impact of mid-latitude targeted observations



Example: results from 1998. Over many cases, where either extra cloud-drift wind measurements or dropsonde data were assimilated in pre-defined sensitive regions, there was a reduction in error in the target verification area.

From Langland et al. July 1999 BAMS article on NORPEX-98 expt.

Targeted observation concept

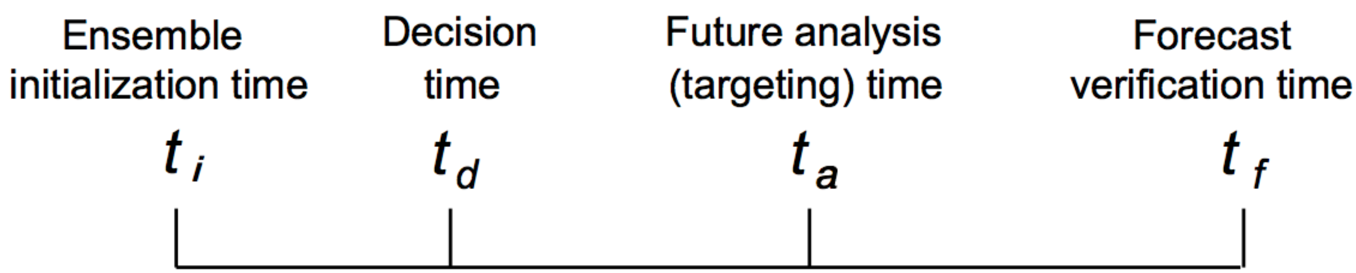
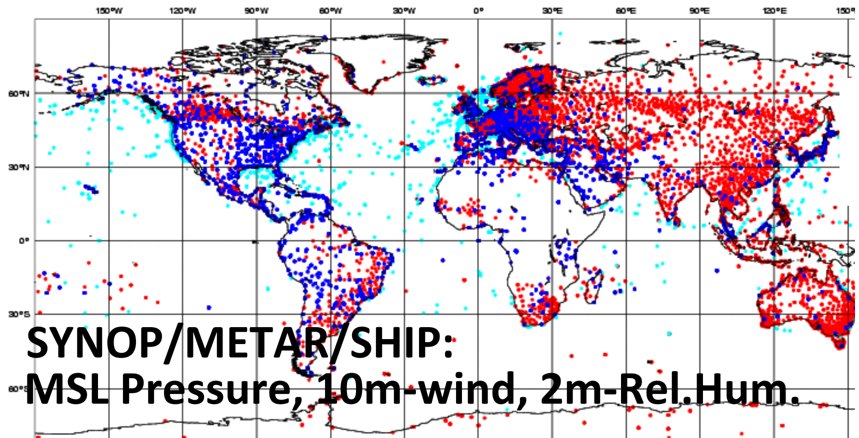


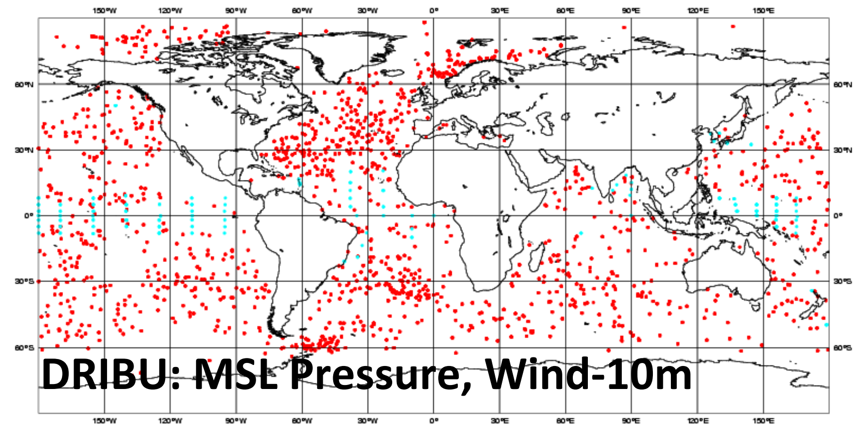
Figure 1. Times involved in the decision making process. Based on an ensemble initialized at time(s) t_i, a decision is made at time t_d to deploy adaptive observational resources at the future analysis time t_a, to improve a forecast (initiated at t_a) valid within a verification region at time t_f.

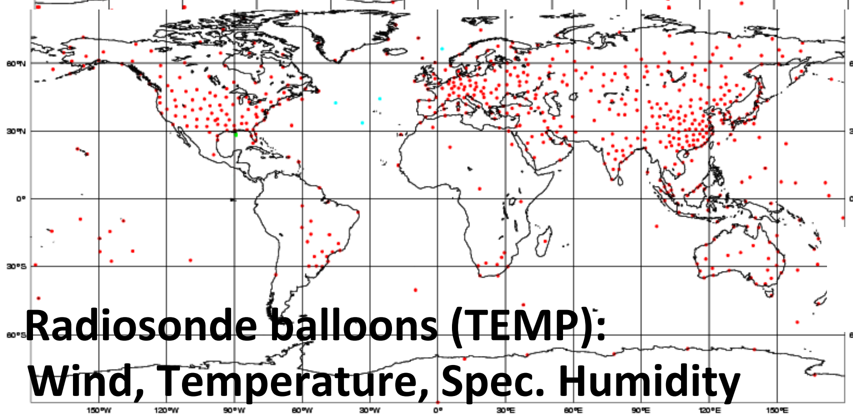
Will mid-latitude dropwindsonde targeting have the same effect in the 2010's?

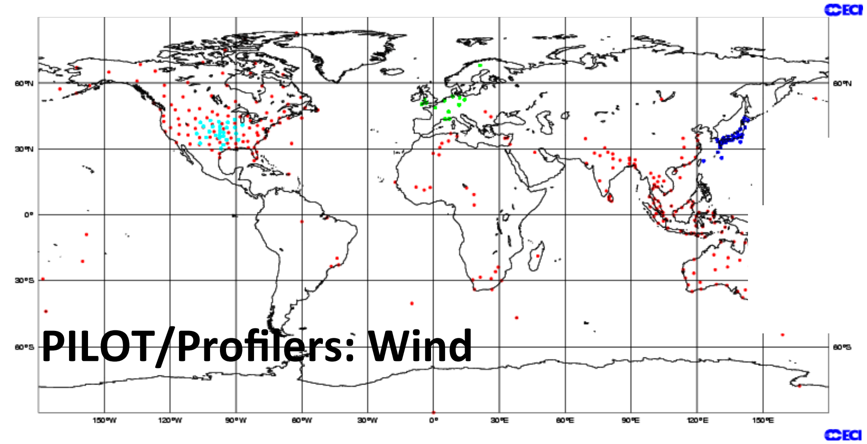
- More observations, especially satellite, so fewer "gaps" in the global observing system.
- Better models.
- Better data assimilation systems.

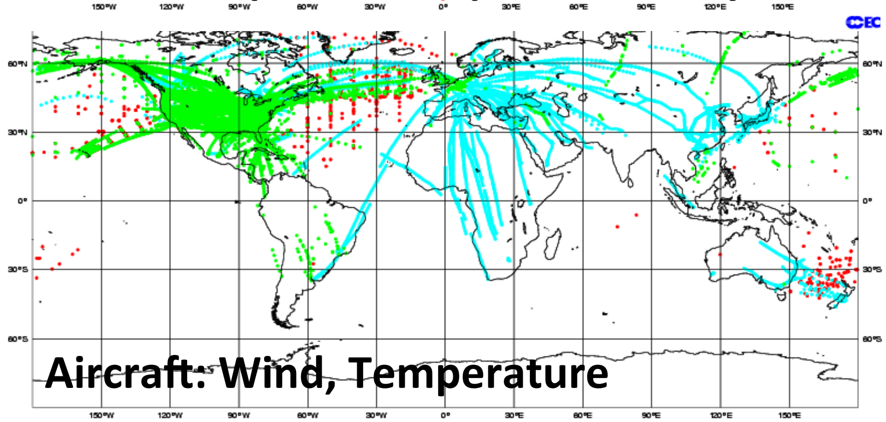
ECMWF: conventional observations used



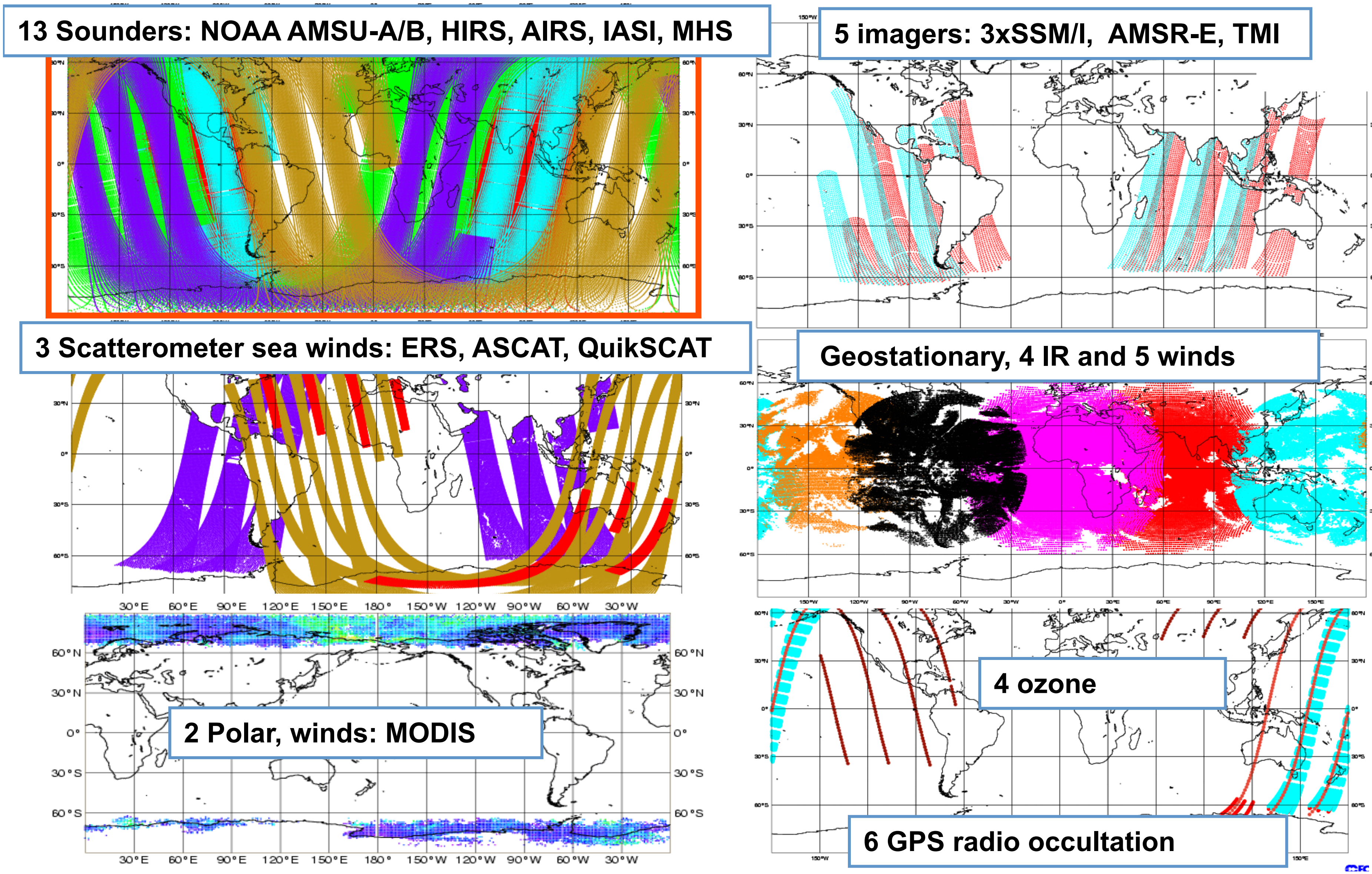




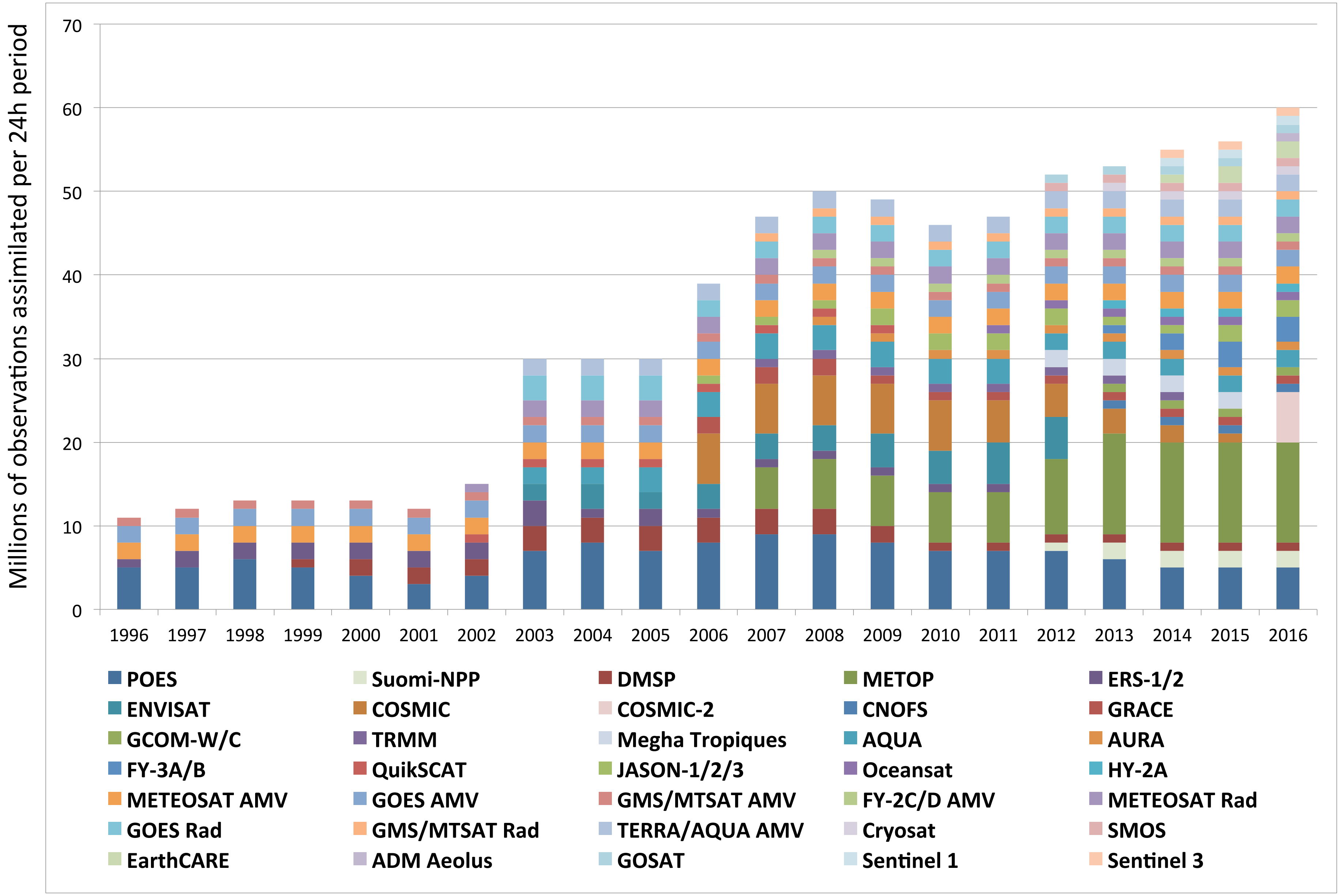




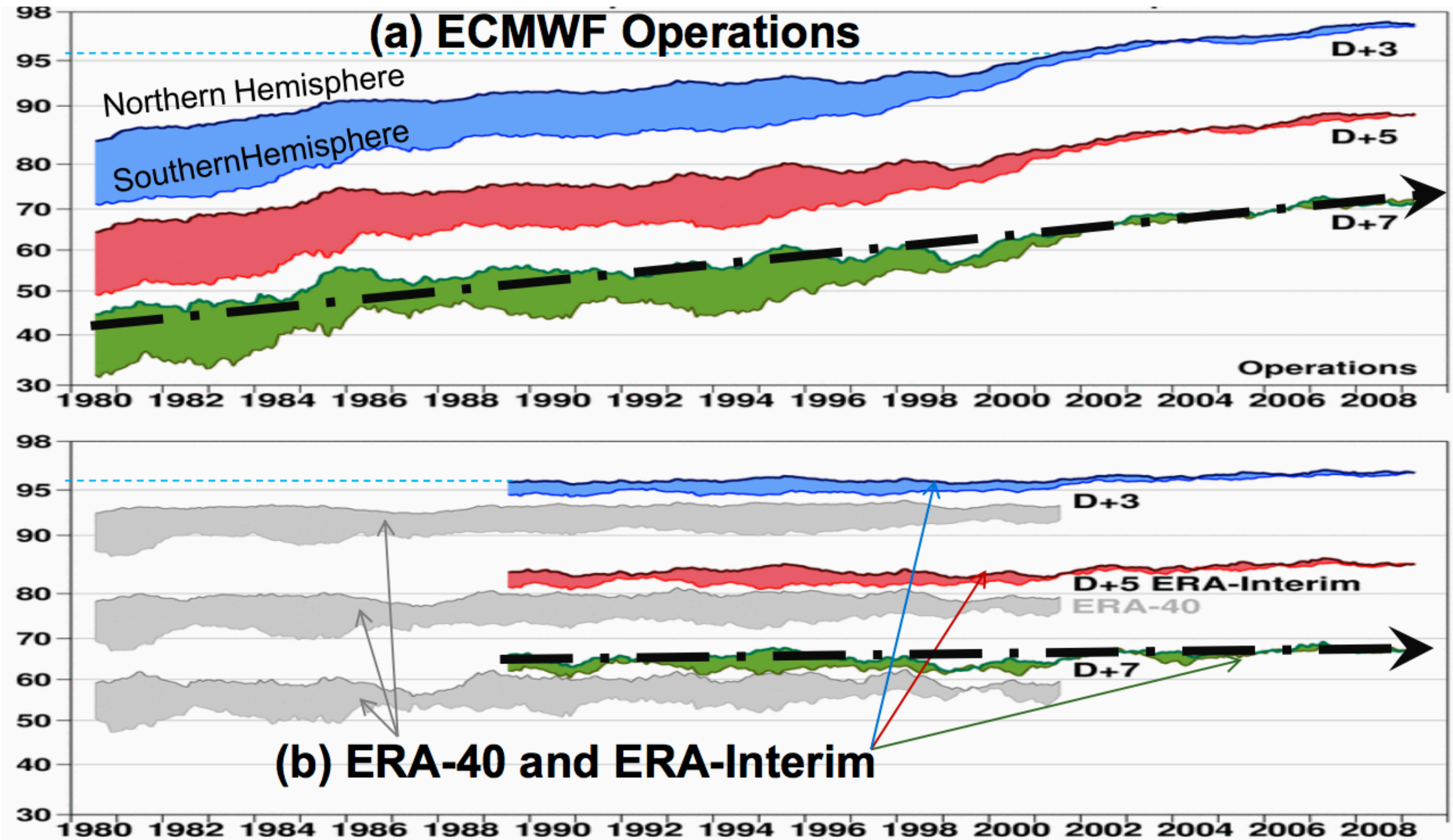
Satellite data sources used in the operational ECMWF analysis



Satellite data usage at ECMWF, past, present and near future



…though it's probably more the improved assimilation techniques and models that have improved skill.



http://www.ecmwf.int/newsevents/training/meteorological_presentations/pdf/DA/ERA.pdf

Are targeted observations still valuable enough to merit expensive plane flights (and staff time to run targeted observation program)?

NOAA's Winter Storms Reconnaissance Program

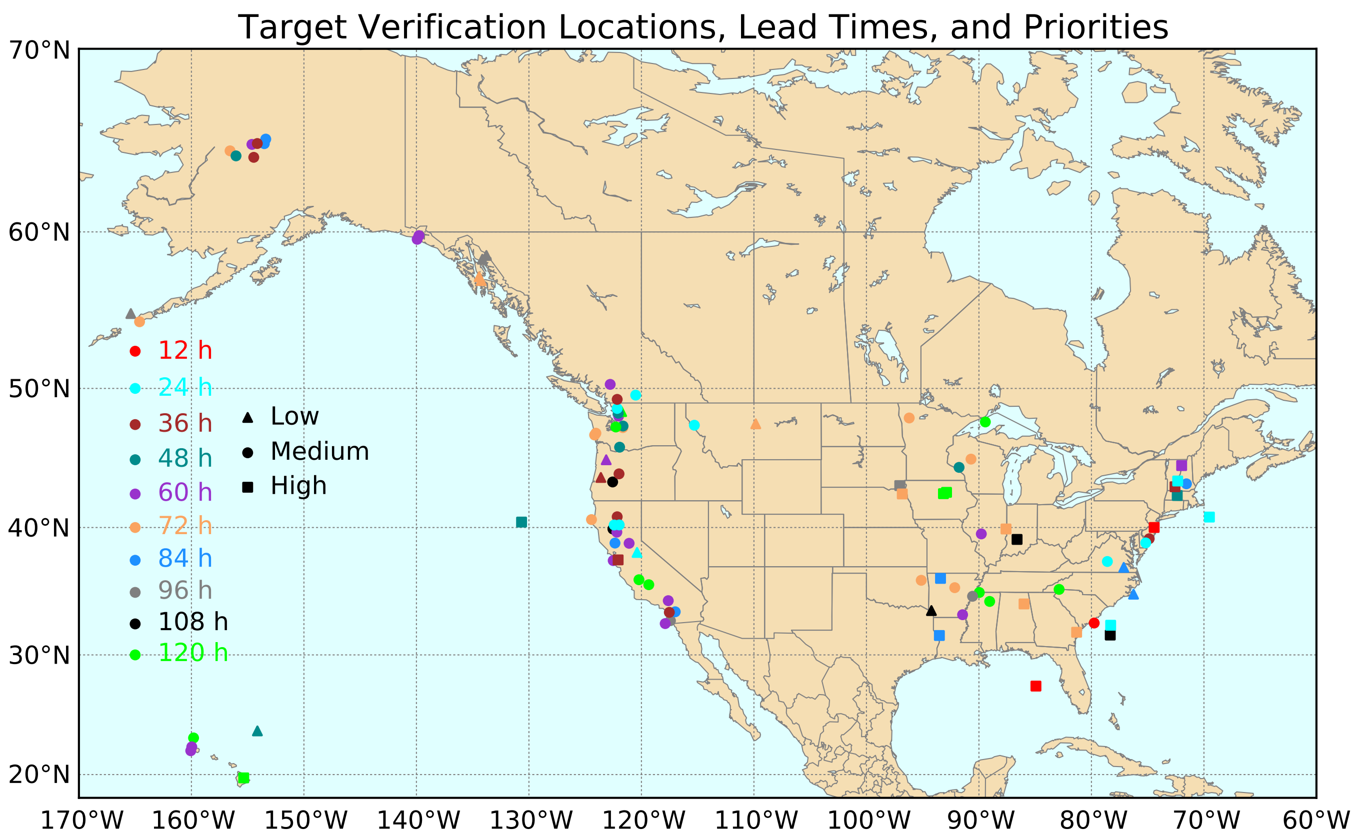
- Each winter day, NOAA forecasters ID systems that may impact US during the next week.
- Forecasters consider automated guidance (ensemble transform Kalman filter, or "ETKF") to identify regions of longer-range forecast uncertainty and what uncertainty in earlier forecast features were primarily responsible.
- Examine ETKF's estimates of potential reduction of analysis/forecast errors were observations taken in a given constellation.
- Determine approximately optimal flight path to reduce analysis errors the most.
- Assign subjective importance to case (low/med/high), determine a target verification region where high-impact forecasts are expected, and suggest reconnaissance mission to pilots.
- Pilots fly the mission and take targeted observations (typically dropwindsondes).
- Extra observations are assimilated alongside the normal observations.

What hasn't been done over the past decade.

- Parallel assimilations and forecasts, with and without the targeted observations, using …
- A modern data assimilation method (e.g., 4D-Var, ensemble Kalman filter, or hybrid), and …
- A modern generation, higher-resolution global forecast model.
- A systematic comparison of forecast errors with and without targeted observations.

2011 WSR Impact Study

- 22 high, 62 medium, 14 low-priority cases, and 776 dropwindsondes deployed.
- Target verification times from +12 to +120 h.



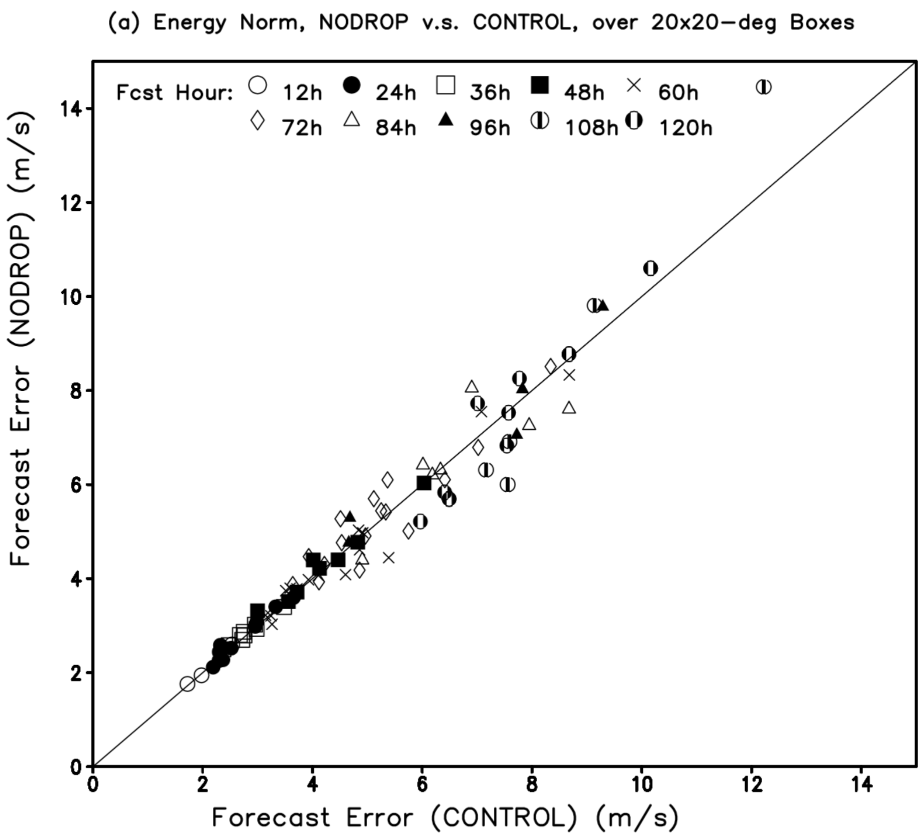
Impact study design

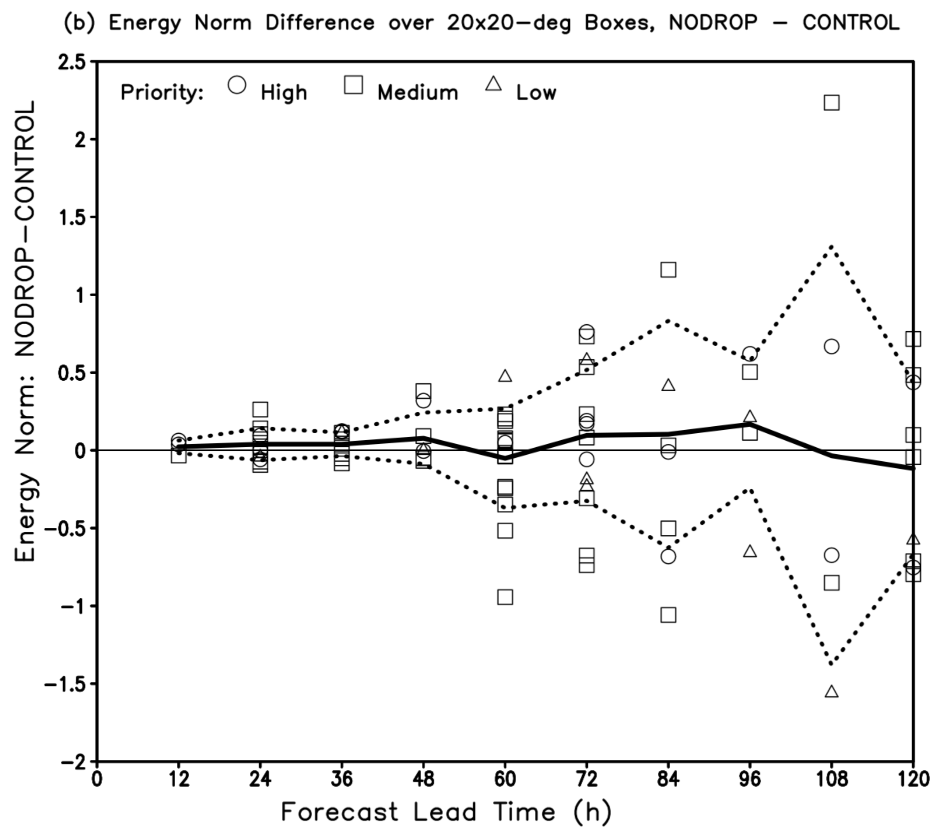
- Assimilate with ECMWF 4D-Var (version 37r2 of IFS; T511L91 outer loop, linearized T159, T159, and T255 inner loops).
- Parallel assimilation and forecast cycles without ("NODROP") and with ("CONTROL").
- Deterministic forecasts to +5 days lead, T511L91
- Verification in ~ total energy norm in 20x20-degree target verification region, and over PNA region. Verification against CONTROL analysis.
- Also: verification of precipitation forecasts over CONUS.

(Approximate) total-energy norm

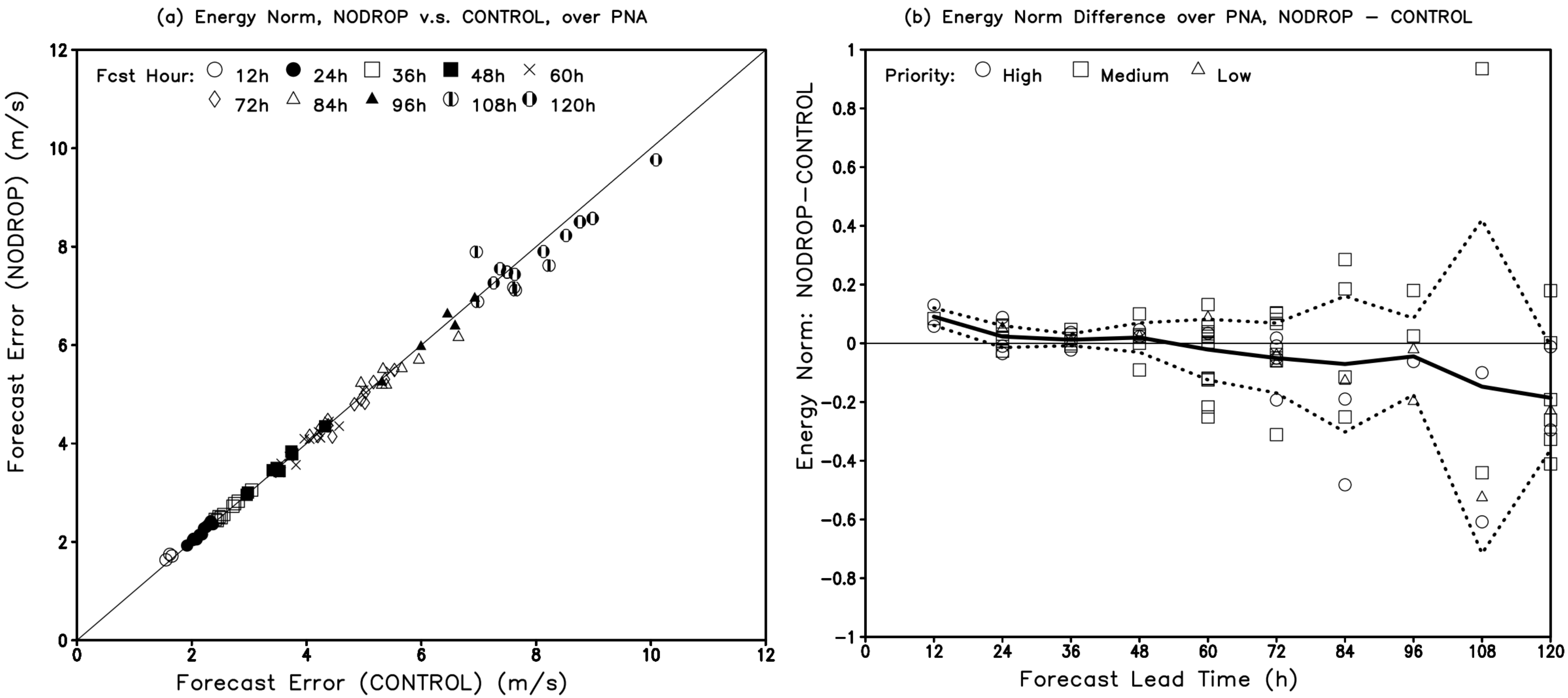
$$E = \left[\frac{1}{2} \int_A \left(\begin{array}{l} \frac{1}{4}\left(\mathbf{u}_{250}^2 + \mathbf{v}_{250}^2 + \frac{c_p}{T_r}\mathbf{t}_{250}^2 \right) + \\ \frac{1}{4}\left(\mathbf{u}_{500}^2 + \mathbf{v}_{500}^2 + \frac{c_p}{T_r}\mathbf{t}_{500}^2 \right) + \\ \frac{1}{4}\left(\mathbf{u}_{850}^2 + \mathbf{v}_{850}^2 + \frac{c_p}{T_r}\mathbf{t}_{850}^2 \right) + \\ \frac{1}{4}\left(\mathbf{u}_{10m}^2 + \mathbf{v}_{10m}^2 + \frac{c_p}{T_r}\mathbf{t}_{2m}^2 \right) + R_d T_r \left(\frac{\mathbf{p}}{P_\mathrm{r}} \right)^2 \end{array} \right) \right]^{1/2},$$

Results over target verification region

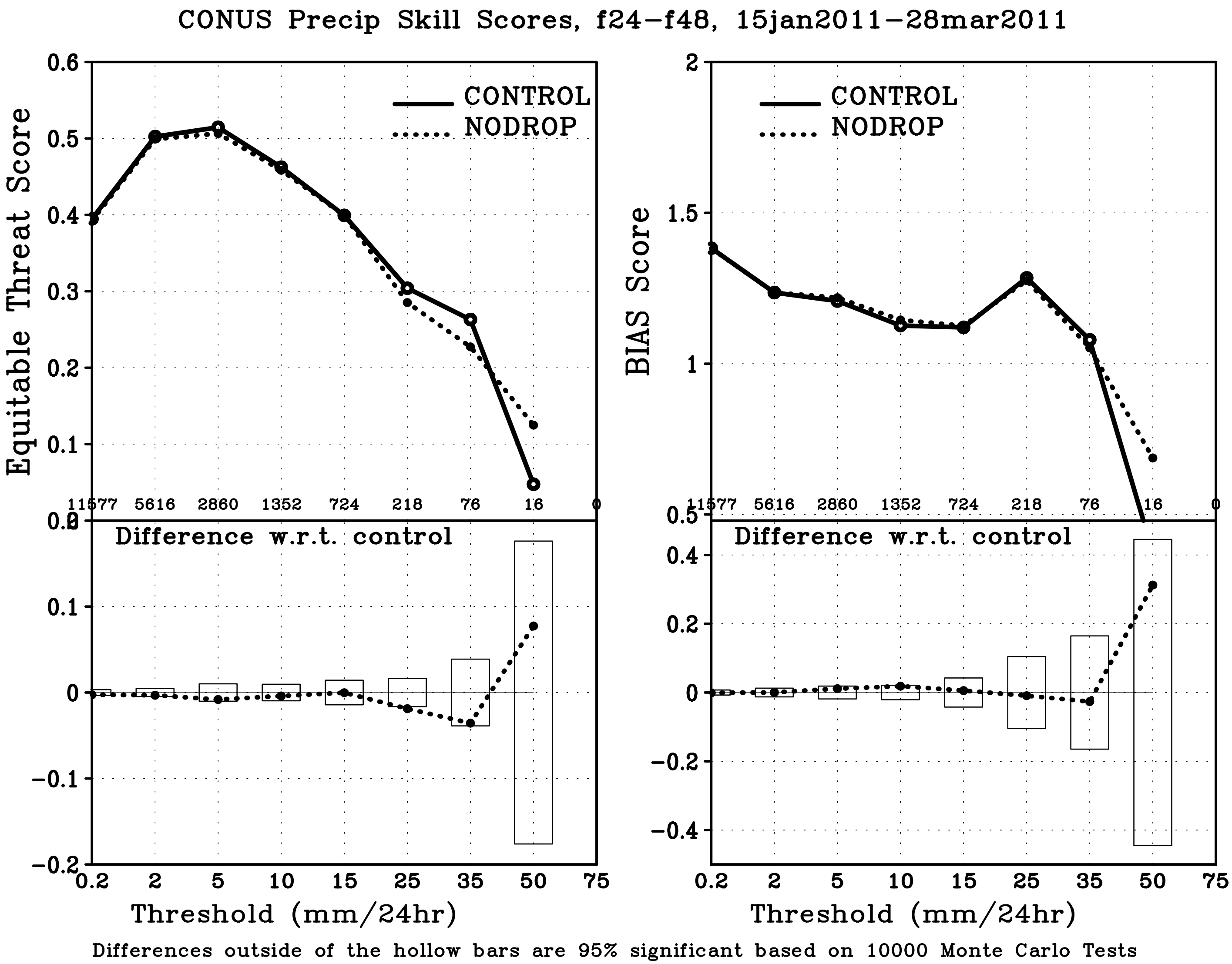




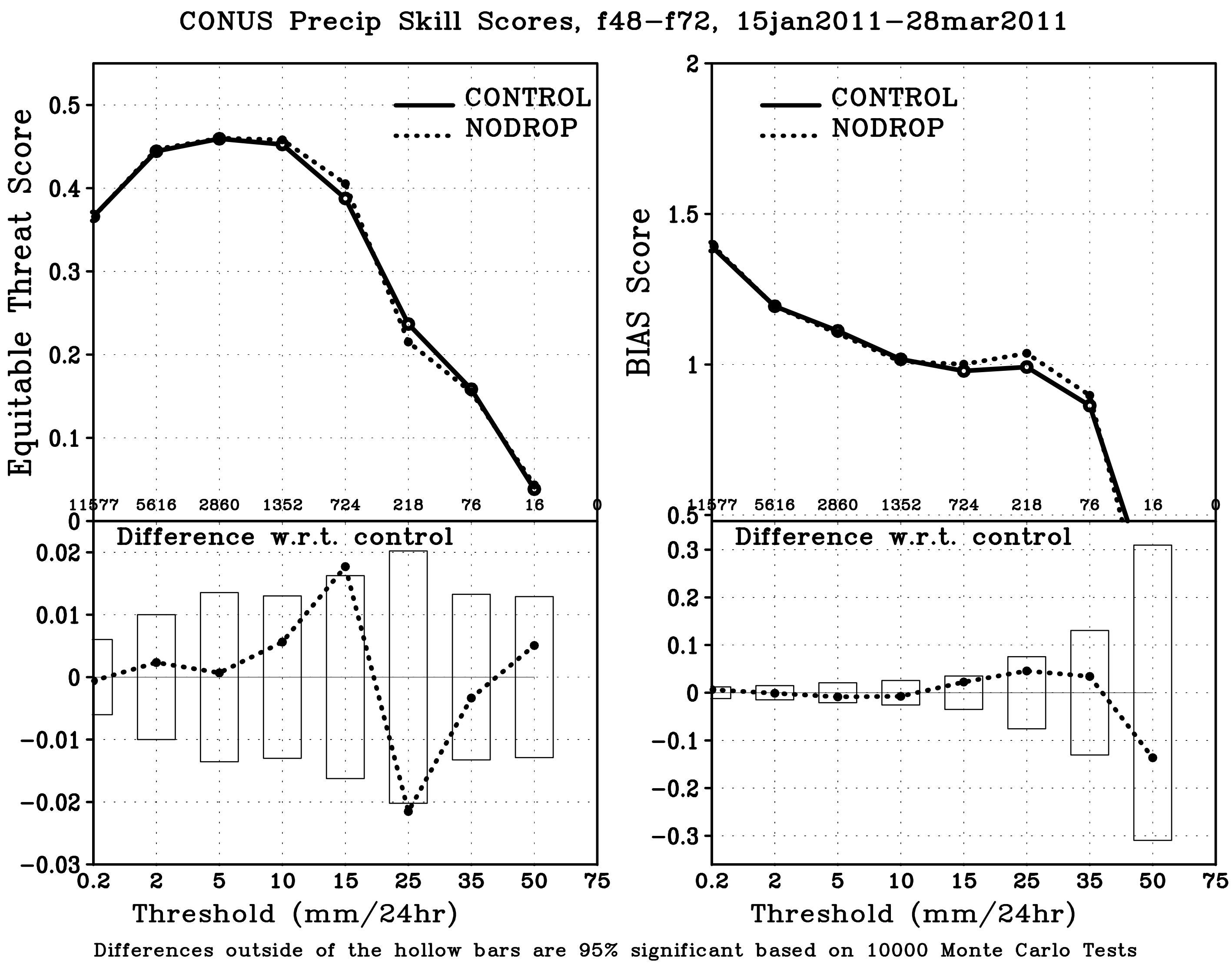
Results over broader PNA region



24-48 h precipitation forecast skill



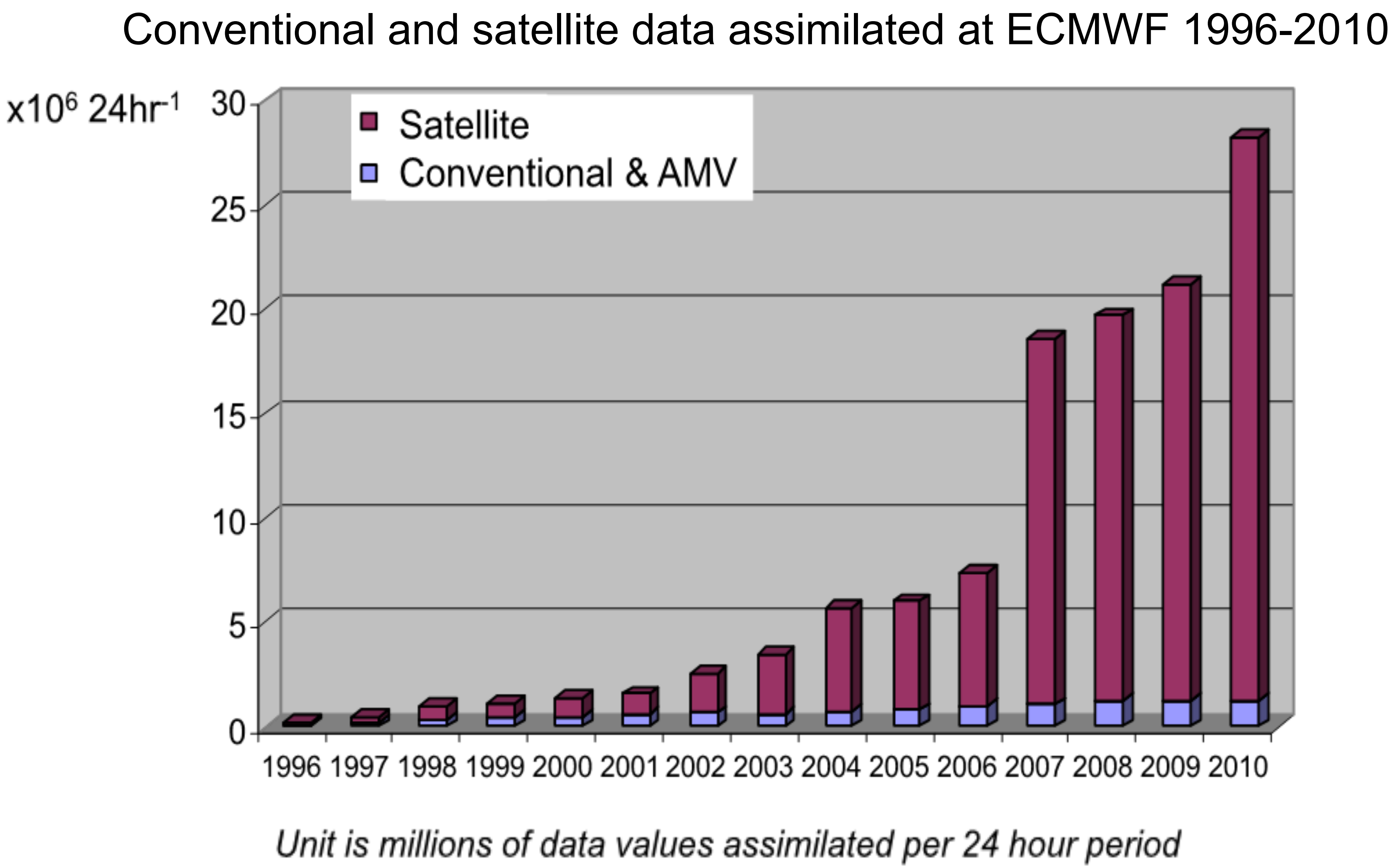
+48-72 h precipitation forecast skill



Conclusions

- No significant positive forecast impact from assimilation of 2011 WSR data in ECMWF system.
- Possible reasons:
  - Incomplete targeting of sometime relatively large initial sensitive regions.
  - Better forecast and assimilation systems.
  - More observations
- What next?
  - Targeted observations more focused on increased use of satellite data (cloud-drift winds, radiances, etc.).

Significant increase in number of observations assimilated



from tinyurl.com/ecmwf-satreport